EXPERIMENTAL DESIGN FOR LARGE-SCALE TESTING OF UNBONDED PCC OVERLAYS AT THE NAPTF

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INTRODUCTION

To obtain the data needed to develop an advanced procedure for designing airfield pavements, the National Airport Pavement Test Facility (NAPTF) was built. The testing vehicle at this facility can simulate repeated loading by aircraft weighing up to 1.2 million pounds. Data from the NAPTF will be used to develop advanced failure models of new pavements and overlays that are applicable to the new generation of aircraft loads, including the six-wheel B-777 gear. A testing program for evaluating the performance of portland cement concrete (PCC) and asphalt concrete (AC) pavements is currently underway, as reported by Hayhoe et al. [1]. The next stage of this testing program will involve accelerated testing of overlays, including PCC overlays.

Recently, the Innovative Pavement Research Foundation (IPRF) contracted the ERES Consultants Division of Applied Research Associates, Inc. to develop an experimental design for a large-scale, accelerated testing program at the NAPTF to obtain performance data on concrete overlays [2]. This paper presents the design of the key parameters of the overlay structure that is proposed for testing at the NAPTF. This includes the selection of the existing pavement parameters (thickness and joint spacing), interlayer thickness, and unbonded overlay parameters. The instrumentation included in the test plan is also described, as is a procedure for data collection.

ASSUMPTIONS

The experimental plan for testing of unbonded PCC overlays presented in this paper was developed with the following assumptions:

- Testing will be conducted at the NAPTF.
- The NAPTF will have three subgrade sections of low, medium, and high strength, each approximately 300 ft long.
- The “existing pavement” (the pavement to be overlaid) will be constructed as a part of the experimental program.
- Further research will be needed beyond the testing program described in this paper; however, the data from this series of testing will clarify numerous issues, and the results may be used to update the overlay design procedure.

OVERVIEW OF THE PROPOSED EXPERIMENTAL PROGRAM

The testing at the NAPTF should be an important step toward improving the current mechanistic-empirical design procedures for unbonded PCC overlays for airport pavements. To achieve this goal, various activities are required, including the following:

- Verification of the structural models of unbonded overlays.
- Development of a mechanistic procedure to incorporate the mechanism of deterioration of unbonded overlays.
- Improved characterization of structural contribution of the underlying pavement, including the effect of the existing pavement condition.

- Calibration of the performance prediction model.
- Development of recommendations for joint matching and for the use of dowels.

The proposed testing program is designed to provide crucial information for accomplishing the above tasks. The requirements of the experimental program are discussed below, including the proposed methods for meeting these requirements.

Structural Model Verification

Validation of structural models is important to ensure that overlay designs are based on realistic estimates of key pavement responses (stresses and deflections). Of interest are the pavement responses under critical combinations of load configuration, slab configuration, and underlying pavement condition. Currently, mechanistic-empirical design procedures for airfield pavements are based on Westergaard theory [3], layered elastic theory [4], or finite element models [5]. Although significant progress has been achieved in the modeling of new PCC pavements, many problems associated with analyzing unbonded overlays still are not resolved. Analysis of the effect of the cracks or other deterioration in the underlying pavement, and interaction between pavement layers remains a challenging problem. Often, the stresses predicted over cracks in the underlying pavement are exceedingly high, and they are not likely to reflect the actual stresses experienced by PCC overlays. Full-scale testing is needed to obtain crucial information for quantifying the true state of stress in unbonded overlays. This information will be valuable for improving the structural models, which will facilitate future design analysis.

The scope of this series of testing includes the investigation of key factors that affect the structural response of unbonded overlays, including the effects of cracks in the underlying pavement, layer interaction, subgrade stiffness, and gear configuration.

<u>Effect of cracks in the underlying pavement.</u> The proposed program calls for testing a full set of possible slab configurations, including fully matched joints (no cracks), a crack in one direction, cracks in two directions, and shattered slabs. The pavement responses obtained from this series of testing will be invaluable in validating analytical predictions and for developing structural models that facilitate analyses of such problems.

<u>Effect of friction and adhesion between the layers.</u> It is a generally accepted practice to ignore friction between the unbonded PCC overlay and the existing pavement. It is highly possible, however, that an AC interlayer provides significant composite action between the PCC layers. By measuring PCC strains in the overlay and existing pavement, one can obtain a degree of composite action under a heavy gear load. Properly accounting for the layer interaction may lead to better prediction of pavement life.

<u>Effect of subgrade stiffness.</u> The PCC overlay thickness required by the existing design procedures depends greatly on subgrade stiffness. However, the properties and conditions of the existing PCC layer may have even greater effect on the overlay responses than subgrade stiffness. Comparing the structural responses of PCC overlay measured on sections with different subgrade properties but the same existing pavement condition and design should

provide valuable information for verification and future development of structural models. NAPTF provides an opportunity to conduct testing on three different levels of subgrade stiffness.

Effect of gear configuration. Comparison of responses from a six-wheel gear loading and four-wheel gear loading will provide information regarding how accurately structural models handle different gear configurations and whether any improvements are required.

Verification of Pavement Deterioration Mechanism

Different design procedures address the deterioration of the existing PCC pavement after overlaying differently. However, how the continued deterioration in the underlying pavement affects the structural response of the overlay are not known. Through measurement of structural responses from strain and deflection gages and heavy weight deflectometer (HWD) deflection data, valuable information can be obtained regarding the effects of any changes in the structural condition of the underlying pavement. The testing program also calls for a visual survey of the underlying slabs after the completion of testing on the overlay on selected sections. The overlay slabs and the interlayer can be removed after the completion of load testing to enable this survey. The presence of additional distresses in the existing pavement and the extent of additional deterioration (amount and severity) will provide valuable information regarding the need to consider such deterioration in the design.

Existing Pavement Condition Characterization and Structural Contribution

Overlay thicknesses required by the current design procedures depend on the assigned structural condition of the existing pavement. Currently, the condition is considered through a subjective condition index (C_r) or the structural condition index (SCI), as reported by Rollings [6]. Although the SCI provides a rational and objective estimate of the pavement condition, the adequacy of the SCI needs to be verified. In particular, the following questions should be answered:

- What is the relative contribution toward the reduction of structural contribution of the existing pavement of the distresses (transverse cracking, longitudinal cracking, corner cracking, shattered cracking, and joint spalling) that affect SCI? Currently, the SCI treats these distresses equally. However, joint spalling may not affect the unbonded overlay behavior at all.
- Does the level of crack deterioration affect the structural contribution of the existing pavement? Currently, different severities of cracking affect SCI significantly.
- How much of the structural contribution of the existing pavement is affected by the severity of cracking and spalling?

To evaluate the effects of different distresses on the overlay structural responses and performance, the following structural conditions of the existing pavement will be simulated for each subgrade type:

- No distresses, matched transverse and longitudinal joints.
- Mismatched transverse and longitudinal joints.

- High-severity longitudinal cracks in the existing pavement.
- High-severity transverse cracks in the existing pavement.
- High-severity shattered slabs.
- High-severity spalled transverse cracks in the existing pavement (low strength subgrade only).
- Low-severity transverse cracks in the existing pavement.

In addition to relative comparison of the effect of different distresses for the same loading and subgrade support conditions, the experiment will allow researchers to investigate the effect of subgrade support and gear geometry on such ranking. If required, information obtained from this experiment will permit modification of the SCI.

Performance Model Calibration

Calibration of the performance prediction model is the most important step in the development of mechanistic-empirical design procedures. The testing program should provide information for the calibration of unbonded PCC overlay cracking models. Although only one overlay thickness is proposed for the testing, it is expected that variability in support conditions (both subgrade and existing pavement) will provide a wide spectrum of PCC responses and observed pavement life. That information, in addition to information obtained from full-scale tests of new pavements (if available), should provide a substantial data for the development and calibration of a performance model.

Development of Design Recommendations

The current overlay design procedures mainly deal with the overlay thickness design. Joint matching or mismatching and the use of dowels may have a significant impact on overlay performance, but not enough data are available to draw any conclusions. A common practice for unbonded PCC overlays of highway pavements is to mismatch joints. FAA circular AC 5320-6D [7] states that overlay contraction joints can be over or within 1 ft of existing expansion, construction, or contraction joints. It also states that if a concrete overlay with a leveling course is used, the joint pattern in the overlay does not have to match the joint pattern in the existing pavement. If joint mismatching results in measurable benefit, the practice should be recommended. If the effects are negligible, no special efforts need to be made to mismatch joints.

In the proposed study, the benefit of joint mismatching will be investigated. The behavior of test sections with matched joints will be compared directly to the behavior of joints mismatched in one or both directions. This comparison will be conducted for three subgrade types and two gear configurations. Therefore, the test will enable the development of specific recommendations regarding joint mismatching.

In terms of doweling, the FAA circular states that dowels should be used in expansion joints and butt-type construction joints. They also must be used in the last three transverse contraction joints from a free edge. Contraction joints in the interior of a slab may be dummy joints aggregate interlock only). In this study, the behavior of overlay sections with doweled contraction joints will be compared with the behavior of undoweled contraction joints. The information obtained can be used for verifying/updating the FAA recommendations.

EXPERIMENTAL PAVEMENT STRUCTURE

Selection of the existing pavement and overlay parameters for full-scale testing is a challenging problem. On the one hand, a too-weak overlay structure may fail after a few load applications and not provide sufficient information to achieve the goals of the experimental program. On the other hand, a too-strong structure may not fail after a very larger number of load applications, which also will not provide information about overlay failure.

The results of tests of new PCC pavements conducted at the NAPTF in March–April 2000 reported by Guo et al. [8] and test strip sections conducted in March 2002 reported by McQueen et al. [9] were used extensively for the selection of the experimental pavement structure parameters. The rigid pavement sections tested in March 2000 had 20-ft joint spacing and sustained only approximately 900 gear passes. A predominant mode of failure was top-down corner cracking caused by a combination of corner loading, slab curling, and warping. The test strip tested in 2002 also indicated that 20- by 20-ft slabs are susceptible to top-down cracking, whereas 15- by 15-ft slabs sustained many more load repetitions and failed in longitudinal cracking, which is more typical mode of failure in the field. The series of tests conducted on 11-in-thick jointed plain concrete pavement (JPCP) slabs with 15-ft joint spacing showed extensive cracking after 4,000 load repetitions if a modified mix design and curing were used. The desirable load capacity for the underlying pavement is about 10 times this level (about 40,000 load passes). Under similar conditions (similar concrete mix, similar curing, and the same joint spacing), 12-in slabs should provide the desired level of load repetitions. Thus, the slab thickness and joint spacing for the underlying pavement were recommended to be 12 in and 15 ft, respectively.

Currently, there are no guidelines available for selection of the interlayer thickness and properties. At this time, however, it is not appropriate to include different interlayer thicknesses or interlayer properties in the full-scale testing effort. Significant analytical work and lab testing should be conducted to design the experiment properly. For this project, the interlayer thickness of 2 in was selected. This thickness was recommended by the NCHRP 10-41 study, which investigated the performance of unbonded concrete overlays for highway pavements.

Based on this analysis and the results of LEDFAA [4], Navy design procedure [10], and mechanistic checks, the overlay slab thickness and joint spacing were selected to be equal to 9 in and 15 ft. Using LEDFAA, the performance life of 9-in PCC overlays was checked for B-777 and B-747 gears. For each gear type, wheel loads of 45,000 and 65,000 lb per wheel were considered. Table 1 presents the results of this analysis. The expected design life of a 9-in overlay under a B-747 gear with a wheel load of 45,000 lb varies from 2,200 (soft subgrade, poor pavement condition) to several million repetitions (strong subgrade, good pavement conditions). A similar performance life is predicted for a B-777 gear. However, according to LEDFAA, for each subgrade type there will be at least one existing pavement condition that will survive at least 20,000 passes and fail not later than after 50,000 passes.

Table 2. Overlay performance life from LEDFAA.

Subgrade CBR	SCI	Number of passes until failure			
		B747-400		B777-200C	
		45000 lb/wheel	65000 lb/wheel	45000 lb/wheel	65000 lb/wheel
4	40	2200	300	3000	400
4	60	14200	700	12200	600
4	80	29300	1000	19900	700
4	100	39200	1200	26100	10000
8	40	10100	700	24900	1600
8	60	53100	2300	146000	4500
8	80	151400	3500	369000	6900
8	100	228500	4600	518000	8500
30	40	35200	2200	196000	9000
30	60	209000	8700	1364000	37700
30	80	1018000	29400	7341000	150200
30	100	3559000	45900	37182000	272000

It can be also observed that an increase in wheel load from 45,000 lb to 65,000 lb in the main gear significantly reduces the predicted overlay life, but even for this loading, sections subjected to B-777 gear loading are not expected to fail if the underlying pavement is in good condition. However, as was discussed above, the research team does not expect so huge a difference in design life for the sections with the same overlay parameters and existing pavement conditions for different subgrades. Considering that LEDFAA predictions for soft subgrade appear to be more realistic, one can conclude that sections with a stiff subgrade will fail after a reasonable number of load applications. Therefore, according to LEDFAA, a 9-in thickness is appropriate for test sections at the NAPTF.

The Navy overlay design procedure was used as an additional check to verify overlay thickness selection. Standard NAVFAC [10] policy requires that Navy design be based on a center (interior) loading Westergaard solution [3] and PCA fatigue beam model [11]. However, the edge stress option is included in the Navy design software to allow the designer to evaluate how a thickness design is impacted by an edge loading condition as compared to an interior loading condition. The effects of various design factors are considered in different ways in different design procedures; therefore, the use of the Navy design program provides an independent appraisal of the overlay design thickness.

According to the Navy design procedure (center slab load location design), all subgrade sections will sustain at least 10,000 gear passes. Only a section with a very poor existing pavement condition (SCI = 40, which corresponds to shattered slabs) will fail earlier. A design check based on the edge loading condition predicts early failures for the B-777 gear on a soft subgrade if the existing pavement is not in excellent condition, but for other subgrades, it predicts a design life greater than 10,000 gear passes. Based on these results, one can conclude that, according to the Navy design procedure, a 9-in thickness is appropriate for test sections at the NAPTF.

The finite element program ISLAB2000 [12] was used for a mechanistic check of the selected overlay thickness. Critical stresses in the overlay caused by a combined action of a gear load, temperature curling, and moisture warping were calculated and compared with calculated critical stresses in the test strip slab. Details of this analysis can be found elsewhere [2]. It was found that the bottom surface stresses predicted by ISLAB2000 for the PCC overlays were much lower than those predicted for the test strip. Therefore, significantly longer resistance to bottom-up cracking can be expected for unbonded overlays than was observed for the test strip slabs. At the same time, the overlay stresses at the top surface were predicted to be somewhere between the stresses predicted for the 15- and 20-ft test strip sections. Therefore, it is reasonable to assume that if the warping conditions and the PCC material properties for the overlay are the same as they were for test strip slabs, then the expected number of load repetitions is between 800 and 5,000. To increase the number of load passes, the built-in curling and moisture warping should be reduced. Therefore, it was recommended to select the overlay thickness and joint spacing equal to 9 in and 15 ft, respectively. It was also recommended to pay special attention to PCC overlay curing during construction.

TEST PLAN

Test sections have been designed of unbonded concrete overlays over a concrete base pavement over three subgrade strengths. The test sections will have a range of joint locations and spacing, and simulated distress conditions. The experimental design assumes that the pavement structure test bed will be 900 ft long by 66 ft wide placed on the underlying subgrade (approximately 10 ft deep). The test site will consist of the prepared test bed with three different subgrade strengths—low, medium, and high strengths (also referred to as L, M, and H herein). After removing the previous test structure, the top surface of the subgrade will be reworked, recompacted, and regraded to meet the following design requirements in terms of CBR equal to 4, 8, and 30 for low, medium, and high strength subgrade sections, respectively.

The test sections on each subgrade type will be 300 ft long, as shown in figure 1, with the low strength subgrade being at the west end of the test track. The medium and high strength subgrades follow towards the east. Each test section is divided into test cells, each of which has a unique combination of test parameters (gear type, underlying slab, overlay condition and joint type). The identification codes L1-N, M2-S, H4, and so on, denote each test cell. For example, L1-N refers to test cell 1, on a low strength subgrade to the north of the centerline. Similarly, H4 refers to test cell 4 on a high strength subgrade, regardless of which side of the centerline the test cell may be located. In addition, all rows and column of slabs in the overlays are assigned letters a, b, c, or d and numbers 1 through 60, respectively (figure 1), and provide a unique identity to each slab. For example, slab c4 is located, based on its position, in the row c and column 4.

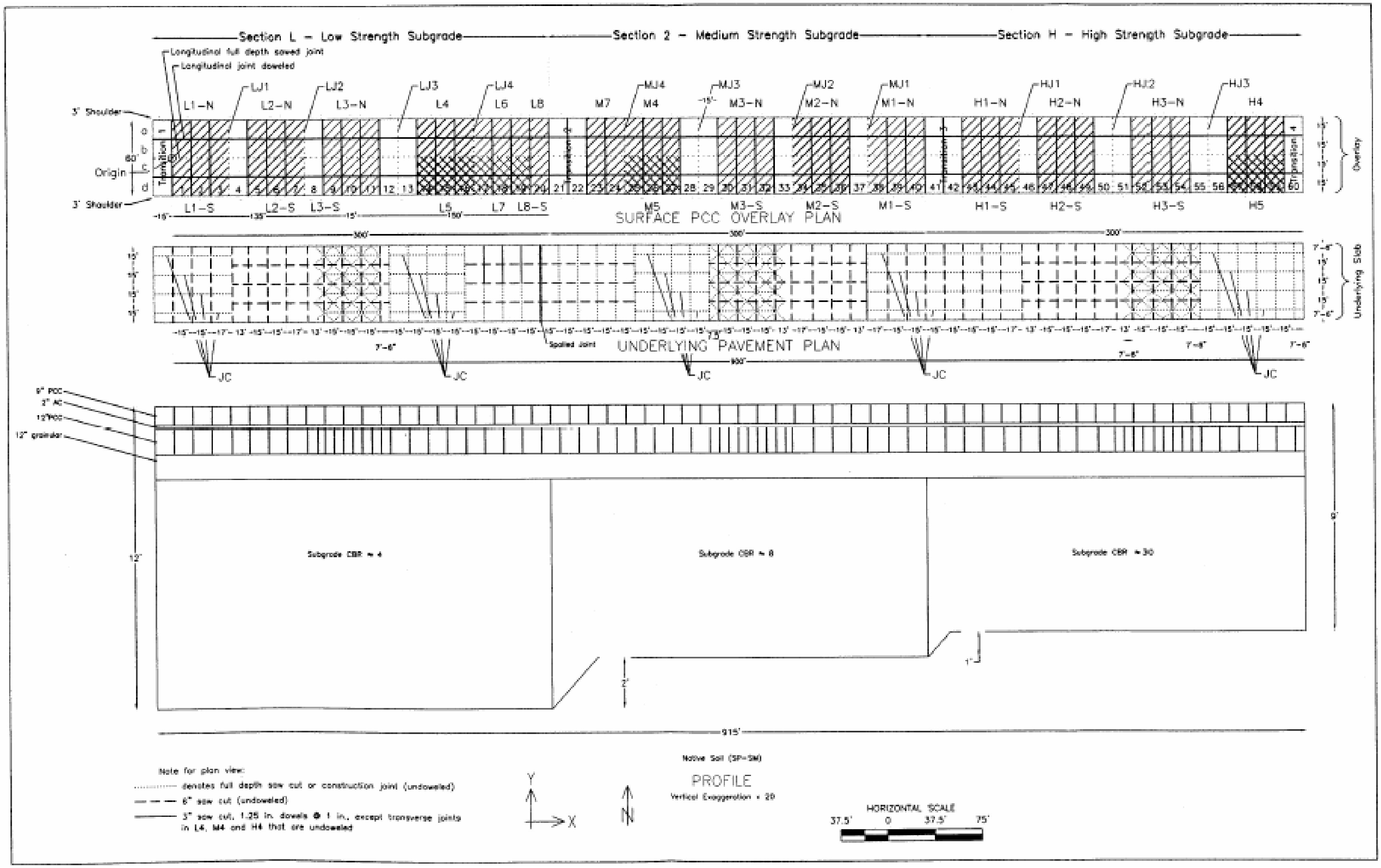

Figure 1. Test track plan view of the underlying pavement and the overlay.

Transition slabs will be provided as marked on figure 1. These transition slabs will not provide response data for analysis. The main purpose of these slabs is to provide sufficient distance for the slabs to develop stress and deformation responses typical of the conditions they are designed for while transitioning from one subgrade type to another or one gear configuration to another.

Transverse and longitudinal joint locations in the underlying slabs have been chosen so that all possible combinations of matched and mismatched transverse and longitudinal joints/cracks are simulated in the experimental matrix. The joints in both directions match and align themselves perfectly on some test cells, namely, L2-N, L2-S, M2-N, M2-S, H2-N, and H2-S. Cells L1-N, L1-S, M1-N, M1-S, H1-N, and H1-S have matched transverse joints but mismatched longitudinal joints. Similarly cells L6, L7, and M7 have mismatched transverse joints and matched longitudinal joints. Finally, cells L4, L5, M4, M5, H4, and H5 have mismatched transverse and longitudinal joints.

The PCC overlay consists of regular contraction transverse joints and several joints connecting test cells with transition slabs. All regular contraction joints are doweled except those in cells L4, M4, and H4. The contraction joints are created by 3-in-deep and 3/16-in-wide saw cuts. In doweled joints, dowel diameter and dowel spacing are 1.25 in and 12 in, respectively. Dowels should not be placed closer than 6 in to the longitudinal edges of the overlay slabs.

Special transverse joints are designed to prevent propagation of a longitudinal crack across a transverse joint from one test cell to another. These joints are either construction joints or created by a full-depth 1/4-in-wide saw cut. The transverse joints in the overlay, identified as type J1, are supported by staggering the joint in the underlying pavement by 2 feet, as shown in figure 2-a. Joints LJ1, MJ1, and HJ1 are of type J1. Transverse joints identified as type J2 are full-depth joints (see figure 2-b). Joints LJ2, LJ3, LJ4, MJ2, MJ3, MJ4, HJ2, and HJ3 are of type J2. Saw cuts in the underlying slabs model joints and cracks of different degree of deterioration of cracks and joints in the existing pavement. Transverse joints matched with the transverse joint in the overlay are assumed to be of moderate level of deterioration and created by saw cuts 6 in deep and 3/16 in wide. Transverse joints mismatched with the transverse joints in the overlay are assumed to be badly deteriorated and created by a full-depth 1/4-in-wide saw cut. Cell L6 has underlying slabs with doweled transverse joints to model low severity cracks. These joints are created by 3-in-deep and 3/16-in-wide saw cuts.

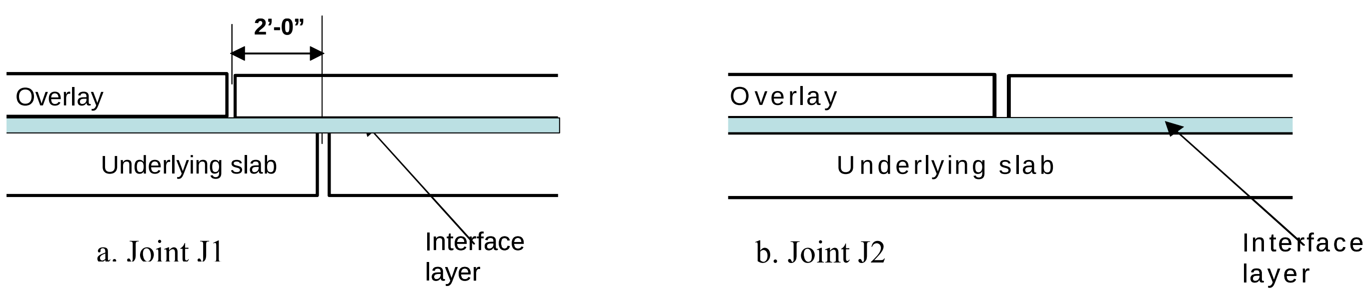

Figure 2. Joint details: a- joint J1; b – joint J2.

Slabs a18, b18, c18, and d18 in test cell L8 will have a spalled transverse joint in the underlying slab created by jackhammer. All loose materials will be removed prior to AC interlayer placement.

The centerline longitudinal joint in the overlay is an undoweled construction joint that should isolate the northern and southern test cells from the propagation of transverse cracks. Longitudinal joints to the north and south of the centerline joint on the overlay will be created by 3-in-deep and 3/16-in-wide saw cuts and will be doweled with 1.25-in dowels with dowel spacing equal to 12 in.

The longitudinal joints in the underlying slabs model joints and cracks of different degrees of deterioration of cracks and joints in the existing pavement. All joints are non-doweled and do not have tie bars. Longitudinal joints identified as JC in the underlying slab simulate high-severity cracking and, hence, are either construction joints or created by full-depth saw cuts. All other longitudinal joints are half-depth joints.

Test cells L3-N, L3-S, M3-N, M3-S, H3-N, and H3-S will have shattered slabs created with full-depth longitudinal and diagonal saw cuts that divide the slabs into six pieces. To achieve this, each slab in the underlying pavement will be sawed full-depth in a pattern as represented by the dashed lines in figure 3. The sawing will be done at 45-degree angles and initiated from the mid-length locations of longitudinal and transverse edges. In addition, the slabs will also be sawed in the longitudinal direction at the slab centerline.

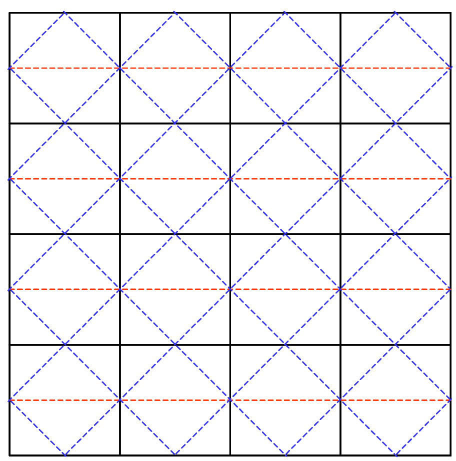

Figure 3. Sawing pattern to create shattered slabs in the existing pavement..

Shoulders will be placed along the entire test track to both the south and north of the test cells. These shoulders are 3 ft wide and will be constructed of 2 in of AC over a 12-in granular layer (P-154) over 22 in of sand.

INSTRUMENTATION PLAN

The sensors to be utilized in the NAPTF test sections can be classified under two broad categories—those that measure the temperature and moisture in the slab, and slab deformations as a result of changes in temperature and moisture, and those that measure slab response as a result of applied loads. Sensors in the former category are referred to as static sensors, and those in the latter category are called dynamic sensors.

Data from static sensors are collected at regular (and desired) time intervals. However, data from dynamic sensors are collected only when the applied wheel loads are active on the pavement system in the vicinity of the gages. The timing of the data collection is facilitated by a series of triggers placed in the transition sections just prior to the test section. These triggers activate the signal-processing unit (SPU) connected to the dynamic sensors as the test vehicle is approaching the test section, which allows the data acquisition system to collect data only from the section that is loaded and makes the process more efficient. As the test vehicle goes past the test sections, the data collection process stops.

It is proposed that static sensor data will be collected at intervals of 15 minutes in the first month after placing the concrete for both the existing pavement and the overlay. Thereafter, data can be collected every hour during the course of the experiments. This rate of data collection will provide an insight into the early age and long-term behavior of existing PCC pavements and overlays. The proposed list of sensors to be utilized in the test is as follows:

- Humidity sensors to measure PCC shrinkage and moisture gradients.
- Thermocouples (type T) to measure temperature gradients at regular intervals.
- Linear Variable Differential Transformer (LVDT) - Joint displacement gages to measure joint opening in the existing slab.
- Linear potentiometers to measure slab lift-off.

The dynamic sensor data will be collected when the sensor is triggered by the approach of the wheel in each pass. The proposed list of sensors to be utilized in the test is as follows:

- Concrete Strain Gages (CSG) to measure strain in PCC overlay and existing slab.
- Thermocouples (type T) to measure temperature gradients during each dynamic measurement.
- Multi Depth Deflectometer (MDD) to measure the deflection at multiple vertical locations at a single point.
- LVDT to measure the surface deflection adjacent to the wheel path (portable device).

Static sensors that record pavement temperature and moisture levels, as well as pavement responses to climatic changes, will be placed in select locations of the test section to provide data that can be applied to the entire test section. In other words, these sensors need not be placed in each test cell. However, dynamic sensors will be placed in each test cell, and pavement response data collected from the dynamic sensors will reflect performance of the overlay on the specific distress conditions of the underlying slab in each test cell.

Sensors will be placed suitably in the test sections to record critical pavement responses, as well as pavement temperature and moisture levels. Figure 4 show a summary of sensor placement in the low-strength subgrade sections. Similar sensor placement was also designed for the medium- and high-strength sections.

DATA COLLECTION PLAN

A comprehensive plan for data collection before, during, and after accelerated load testing of unbonded PCC overlays at the NAPTF was developed as a part of the experimental program.. This plan includes the following:

- Data collection before accelerated load testing (laboratory testing of the pavement layer materials and nondestructive testing of the pavement layers during and after construction).
- Data collection during accelerated load testing:
  - Accelerated load testing with aircraft gear.
  - Nondestructive testing.
  - Surface profile measurement.
- Data collection after accelerated load testing (nondestructive testing and post-traffic evaluation of the interlayer and existing slab).

These data will be collected in addition to the substantial data collection efforts that will be performed as part of construction quality assurance/quality control (QA/QC). The details for each test item are presented below.

Accelerated trafficking of the overlay should be conducted in three stages, as follows:

- Elastic response loading.
- Main loading.
- Overloading.

Stresses in concrete pavements are very sensitive to the load position. Simulation of traffic wander in accelerated testing is important to ensure that the effects of traffic wander on pavement performance are reflected in the test results. Studies have shown that the traffic wander can be assumed normally distributed, and the loading scheme used at NAPTF was designed to approximate normal distribution. Figure 5 shows the typical wander pattern used at NAPTF. The gear loads are applied over nine discrete traffic paths (tracks), and the number of loads applied in each track is selected to approximate normal distribution with typical standard deviation for channelized traffic (30.5 in). The traffic paths are spaced 10 in apart, which provides partial overlapping of tire footprints that adequately simulates the continuous distribution experienced in the field. The load frequency in each track resulting from this loading scheme is shown in figure 5.

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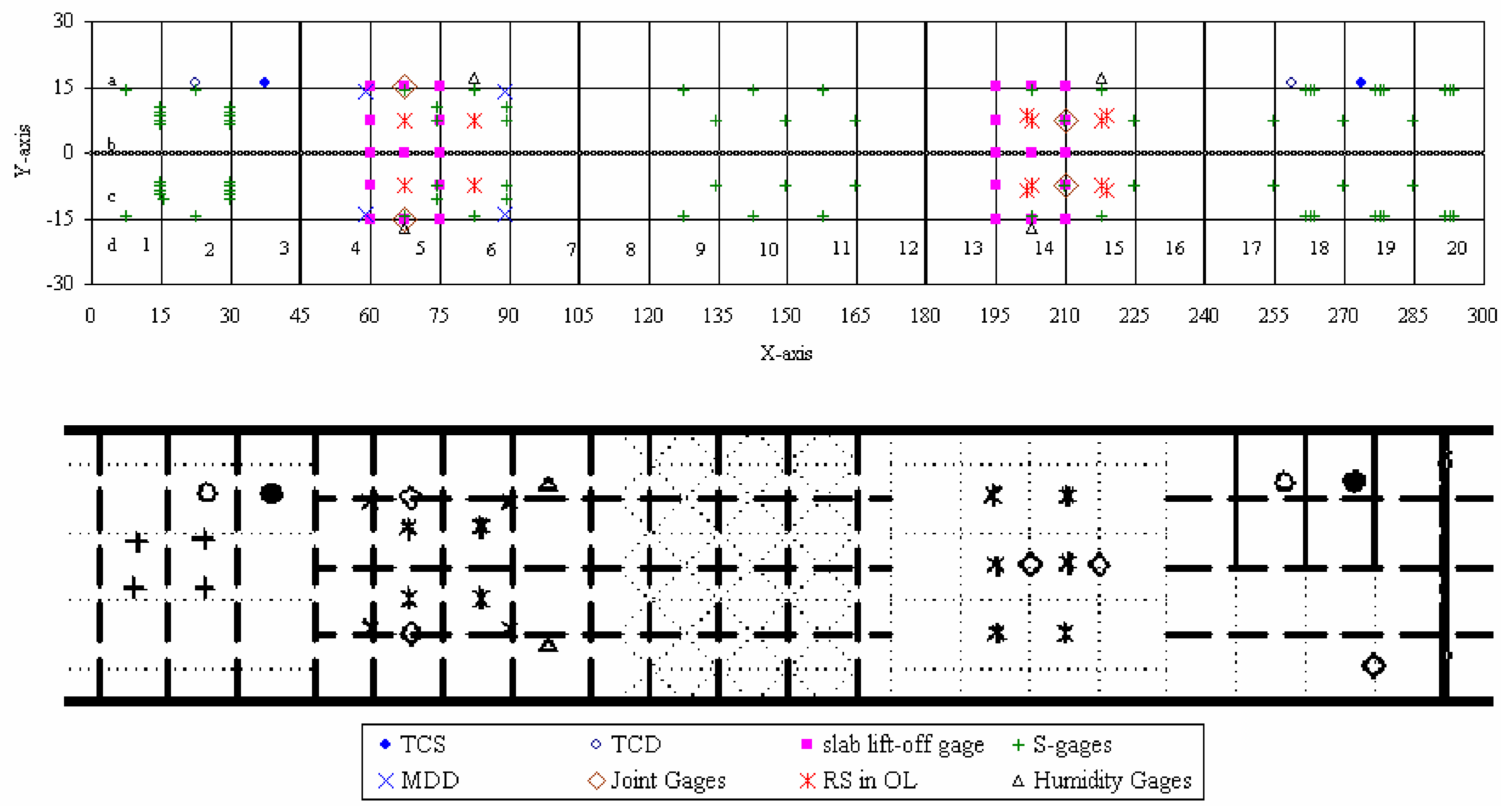

Figure 4. Sensor placement in the low strength subgrade section.

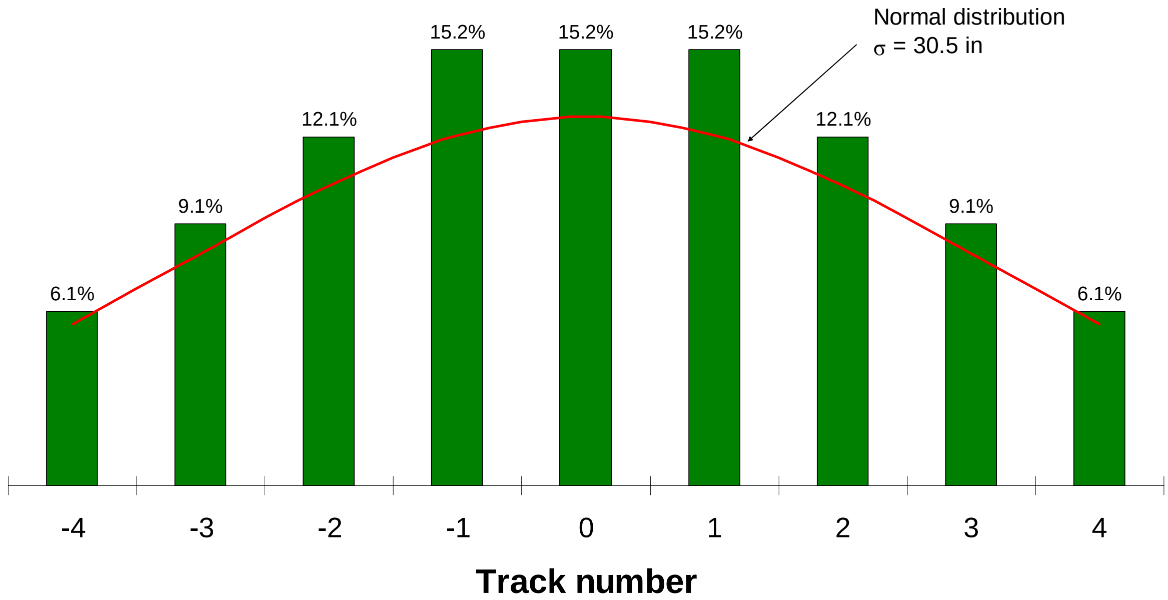

Figure 5. Load frequency in each track due to the loading pattern used at NAPTF.

During the first stage, four complete traffic wander cycles (two cycles at each of two different load levels) should be applied using the actual gears that will be used in the accelerated load testing. The recommended loads for this testing are gear loadings from 10,000 lb per wheel to 30,000 lb per wheel (tire pressures equal to 200 psi) moving at 5 mph. The main objective of this loading is to provide elastic response measurements. That information may be used to accomplish the following:

- Compare the responses under static and moving loads.
- Compare the responses under traffic loading with those under HWD loads.
- Compare the measured and computed responses.
- Study the effect of wheel interaction on stresses from high-speed gear loading by comparing dual tandem and dual tridem stresses.

The main traffic loading consists of up to 750 complete traffic wander cycles (49,500 load passes) applied with aircraft gears at the load level of 45,000 lb for each wheel. The sections that do not fail during these loading cycles will be trafficked by gear loading at 55,000 lb per wheel.

The capability of the NAPTF load frame to simulate dual tandem and dual tridem gear configurations will be utilized fully in this test program. In the low-strength subgrade sections, for the transverse joint in cells L1, L2, and L3, the slabs to the north of the centerline (L1-N, L2-N, and L3-N) will be loaded with a dual tandem gear, while the slabs to the south of the centerline (L1-S, L2-S, and L3-S) will be loaded with a dual tridem gear configuration. As the axle approaches the slab to the east of joint LJ3, the fore dual wheels of the tridem gear to the south of the centerline are lifted off the ground and will exert no tire pressure on the slabs. Therefore, the cells to the east of LJ3 (cells L5, L7, and L8) will be loaded by a tandem gear configuration.

Similarly, while cells M7, M5, and H5 will be loaded with a tandem gear, cells M3-S, M2-S, M1-S, H1-S, H2-S, and H3-S will be loaded with a tridem gear configuration. It is important to note that all cells to the north of the centerline will be loaded with a tandem gear configuration.

The critical stresses in concrete pavements are very sensitive to the load position. Maximum stresses occur when the loads are placed on or very close to a joint, and the stresses drop off rapidly as the load is moved away from the joint. The critical load positions and the damage locations for longitudinal and transverse cracking are shown in figure 6.

The recommended load placements for dual tandem (B747) and dual tridem (B777) aircraft gears are shown in figure 7. The mean wheel location is the loading condition that places the outside edge of the outer wheel on the doweled longitudinal joint on each. 10-in steps are used for traffic paths. This is a highly efficient loading scheme in which about 80 percent of load passes produce a critical coverage for either longitudinal or transverse cracking. Loading in some tracks (e.g., Track -1 for B747 gear) produces a critical coverage for both transverse and longitudinal cracking. The pass-to-coverage ratio for the recommended loading scheme is about 2.7 for longitudinal-edge loading and about 2.0 for transverse-edge loading.

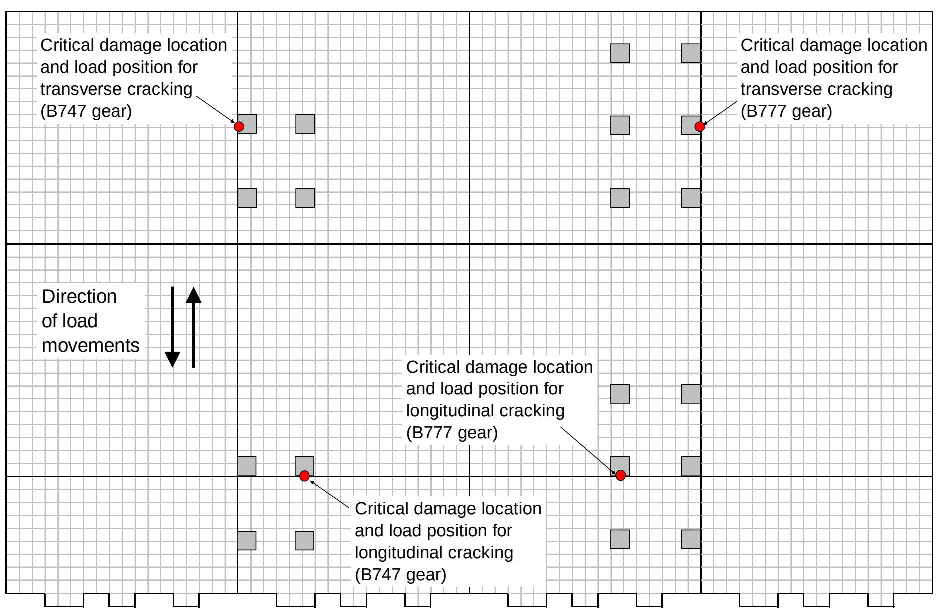

Figure 6. Critical load positions and damage locations.

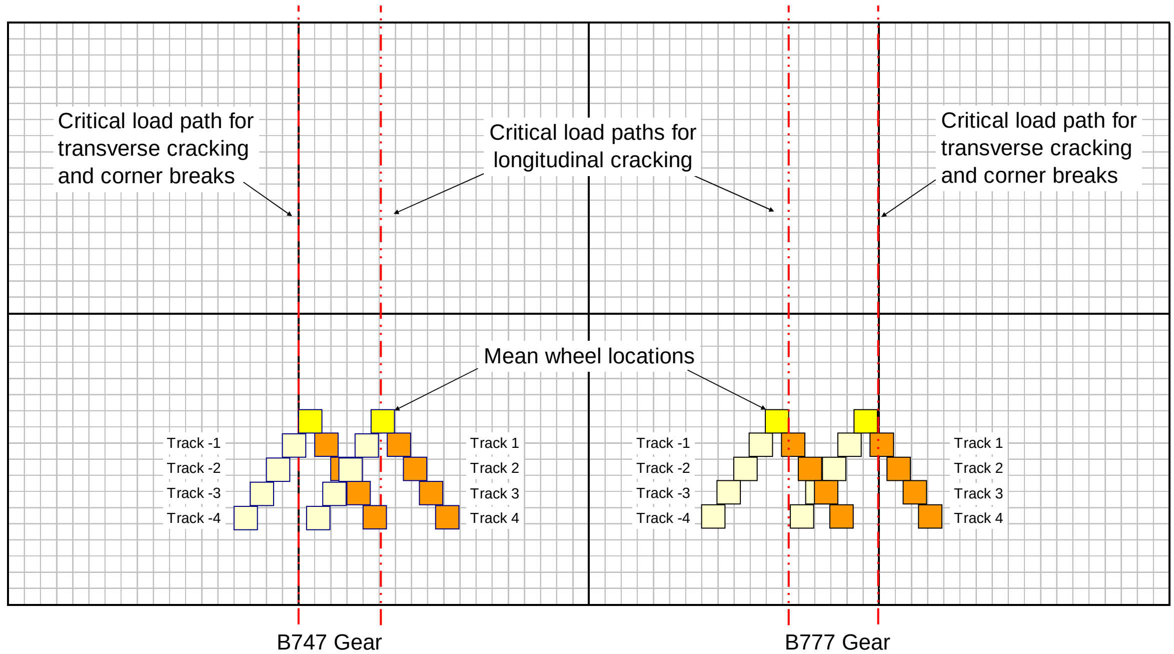

Figure 7. Recommended load paths.

After every 990 load passes, the overlay condition should be evaluated and all cracks and their condition recorded. The PCI should be calculated at this time also. It will provide useful data quickly and cost-effectively.

CONCLUSIONS

A comprehensive experimental program was developed for a large-scale, accelerated testing program at the FAA National Airfield Pavement Test Facility to obtain performance data on concrete overlays. The program calls for the construction of unbonded PCC overlay over a specially constructed underlying PCC pavement that has simulated distresses of different types and severity levels. It includes an experimental design, construction plan, instrumentation plan, construction scheduler and QA/QC procedure, experimental plan, and data analysis roadmap. To ensure that the testing program is implementable, the plan was developed considering the testing capability of the NAPTF, and the plan utilizes the currently available infrastructure of the facility. The proposed series of testing will be an important step toward improving mechanistic-empirical design procedures for unbonded PCC overlays of airport pavements.

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